To: Bruce Guenther
Harry Montgomery
From: Dan Knowles
Ed Knight

June 7, 1995

Subject: OBC BB Polarization

Reference: PL3095-N04385, #2083, "MODIS OBC BB Polarization," by J. Young, 28 Nov. 1994.

Introduction

In the referenced memo, Jim Young analyzes the polarization of the OBC BB and concludes that its effects are negligible. He reports polarization < 0.3% based on measurements of Anodized Aluminum Type II and Type III and a simple V-Groove model. According to this memo, this degree of polarization has an insignificant effect on the effective emissivity of the blackbody and "should pose no appreciable radiometric calibration uncertainty."

However, Jim's model assumes all light incident on the blackbody undergoes four reflections. This is an idealization of the V-groove geometry. Current estimates predict that 10% of the light from the blackbody will come from the tips and groove bottoms where it will have less than four full bounces.

We have modified Jim's model to account for the tips and edges. This light only undergoes one bounce. We start with the data giving reflectance of the surface as a function of angle. We assume that the light reflecting from the tips can come from any angle and average the measured reflectance values over angle. We then add the tip reflectance and 4-bounce reflectance using a user defined weighting factor. The effective emissivity for each polarization is one minus the reflectance and the effective blackbody emissivity is the average of the two polarizations.

Results

Tables 1-3 present the results for 0%, 10%, and 100% weighting factors. As expected, the 0% results match Jim Young's results for the 4-bounce V Groove. P1 and p2 are the two polarizations used in Young's memo. The 100% results match the flate plate measurements cited in the reference. In these tables, the Spec. Status column determines if the emissivity is larger (passes) or smaller (fails) than 0.992, the current blackbody emissivity specification.

Figures 1 and 2 show the effective emissivity and polarization as a function of the weighting factor for Type II Anodize and figures 3 and 4 show the effective emissivity and polarization for Type III Anodize. Since we expect to have weighting factors around 10%, we have blown up the scales in Figures 1a, 2a, 3a, and 4a. The tolerance on the emissivity values is +/- 0.004, which is why we have set the scale on plots 1a and 2a to be 0.988 to 1.0. Values that are below the 0.988 miss the desired emissivity value by more than the allowed tolerance. The decrease in emissivity is linear with the percentage of light only undergoing one bounce. At the current expected case of 10%, the effective emissivity is between 0.978 and 0.997. The polarization could be between 0% and 1%, depending on the mix of Type II and Type III anodize and the wavelength.

Conclusion

From this analysis, it appears that we may in fact have a small but possibly significant residual polarization of the on-board blackbody. Given the simplistic assumptions, it appears that the emissivity drops below our desired value of 0.992 for some bands. We believe that further study, both of the effect and of its effect on the radiometric calibration, is warranted.

Polarization Effects on the OBC Blackbody Emissivity

Type II anodized aluminum

Wavelength	BB emissivity		Average	Spec Status	FF
µm	p1	p2	(p1+p2)/2		abs((p1-p2)/(p1+p2))
4	1.0000	0.9999	1.0000	Pass	0.0000
5	1.0000	0.9999	0.9999	Pass	0.0001
6	1.0000	0.9999	1.0000	Pass	0.0000
7	1.0000	1.0000	1.0000	Pass	0.0000
8	1.0000	1.0000	1.0000	Pass	0.0000
9	1.0000	1.0000	1.0000	Pass	0.0000
10	1.0000	1.0000	1.0000	Pass	0.0000
11	1.0000	1.0000	1.0000	Pass	0.0000
12	1.0000	1.0000	1.0000	Pass	0.0000
13	1.0000	0.9999	1.0000	Pass	0.0000
14	1.0000	0.9997	0.9998	Pass	0.0001

Single Bounce Weight 0%

Type III anodized aluminum

Wavelength	BB emissivity		Average	Spec Status	FF
µm	p1	p2	(p1+p2)/2	Fail if	abs((p1-p2)/(p1+p2))
4	1.0000	1.0000	1.0000	Pass	0.0000
5	1.0000	1.0000	1.0000	Pass	0.0000
6	1.0000	1.0000	1.0000	Pass	0.0000
7	1.0000	1.0000	1.0000	Pass	0.0000
8	1.0000	1.0000	1.0000	Pass	0.0000
9	1.0000	1.0000	1.0000	Pass	0.0000
10	1.0000	1.0000	1.0000	Pass	0.0000
11	1.0000	0.9999	1.0000	Pass	0.0000
12	1.0000	0.9990	0.9995	Pass	0.0005
13	1.0000	0.9974	0.9987	Pass	0.0013
14	0.9998	0.9954	0.9976	Pass	0.0022

Table 1

Polarization Effects on the OBC Blackbody Emissivity

Type II anodized aluminum

Wavelength	BB emissivity		Average	Spec Status	PF
µm	p1	p2	(p1+p2)/2		abs((p1-p2)/(p1+p2))
4	0.9952	0.9884	0.9918	Fail	0.0034
5	0.9945	0.9881	0.9913	Fail	0.0032
6	0.9962	0.9904	0.9933	Pass	0.0029
7	0.9977	0.9932	0.9955	Pass	0.0023
8	0.9987	0.9960	0.9974	Pass	0.0014
9	0.9987	0.9937	0.9962	Pass	0.0025
10	0.9987	0.9930	0.9959	Pass	0.0029
11	0.9982	0.9920	0.9951	Pass	0.0031
12	0.9975	0.9902	0.9939	Pass	0.0037
13	0.9965	0.9882	0.9923	Pass	0.0042
14	0.9947	0.9835	0.9891	Fail	0.0057

Single Bounce Weight 10%

Type III anodized aluminum

Wavelength	BB emissivity		Average	Spec Status	PF
µm	p1	p2	(p1+p2)/2	Fail if	abs((p1-p2)/(p1+p2))
4	0.9975	0.9910	0.9942	Pass	0.0033
5	0.9975	0.9915	0.9945	Pass	0.0030
6	0.9982	0.9922	0.9952	Pass	0.0030
7	0.9987	0.9942	0.9965	Pass	0.0023
8	0.9990	0.9965	0.9977	Pass	0.0013
9	0.9990	0.9942	0.9966	Pass	0.0024
10	0.9987	0.9965	0.9976	Pass	0.0011
11	0.9965	0.9877	0.9921	Pass	0.0044
12	0.9927	0.9781	0.9854	Fail	0.0074
13	0.9922	0.9721	0.9822	Fail	0.0102
14	0.9878	0.9674	0.9776	Fail	0.0104

Table 2

Polarization Effects on the OBC Blackbody Emissivity

Type II anodized aluminum

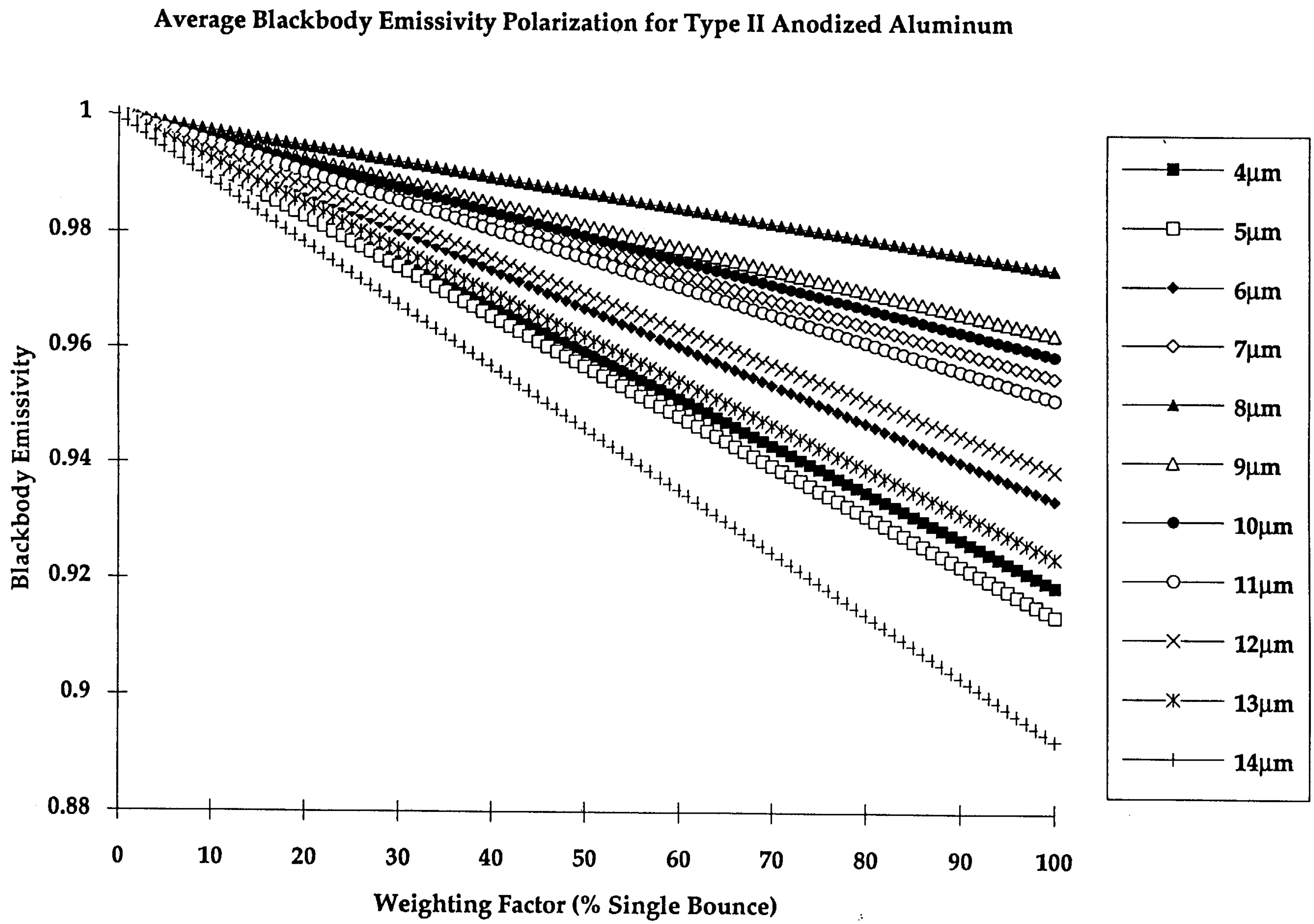
Wavelength	BB emissivity		Average	Spec Status	PF
µm	p1	p2	(p1+p2)/2		abs((p1-p2)/(p1+p2))
4	0.9525	0.8850	0.9188	Fail	0.0367
5	0.9450	0.8825	0.9138	Fail	0.0342
6	0.9625	0.9050	0.9338	Fail	0.0308
7	0.9775	0.9325	0.9550	Fail	0.0236
8	0.9875	0.9600	0.9738	Fail	0.0141
9	0.9875	0.9375	0.9625	Fail	0.0260
10	0.9875	0.9300	0.9588	Fail	0.0300
11	0.9825	0.9200	0.9513	Fail	0.0329
12	0.9750	0.9025	0.9388	Fail	0.0386
13	0.9650	0.8825	0.9238	Fail	0.0447
14	0.9475	0.8375	0.8925	Fail	0.0616

Single Bounce Weight 100%

Type III anodized aluminum

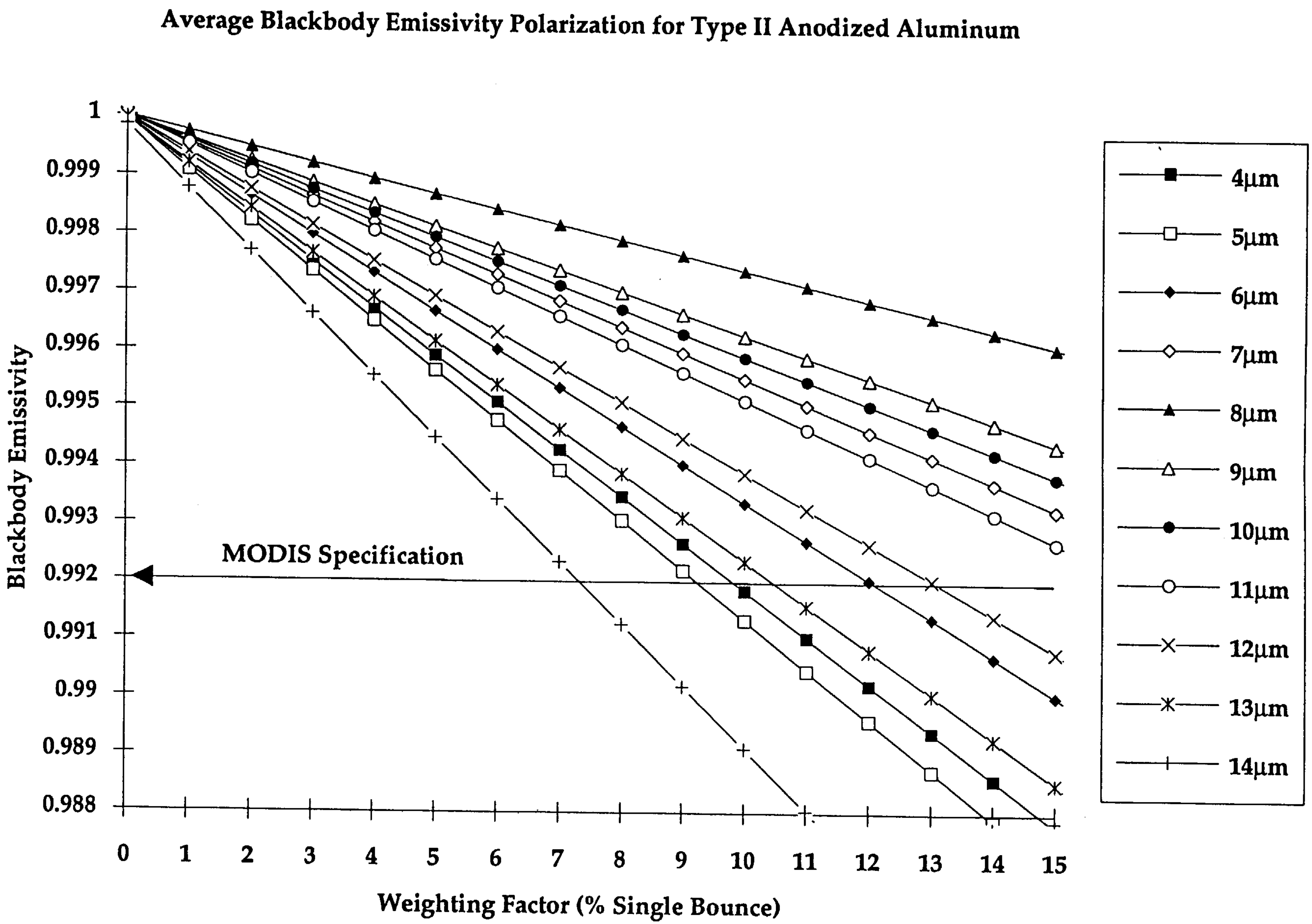
Wavelength	BB emissivity		Average	Spec Status	PF
µm	p1	p2	(p1+p2)/2	Fail if	abs((p1-p2)/(p1+p2))
4	0.9750	0.9100	0.9425	Fail	0.0345
5	0.9750	0.9150	0.9450	Fail	0.0317
6	0.9825	0.9225	0.9525	Fail	0.0315
7	0.9875	0.9425	0.9650	Fail	0.0233
8	0.9900	0.9650	0.9775	Fail	0.0128
9	0.9900	0.9425	0.9663	Fail	0.0246
10	0.9875	0.9650	0.9763	Fail	0.0115
11	0.9650	0.8775	0.9213	Fail	0.0475
12	0.9275	0.7900	0.8588	Fail	0.0801
13	0.9225	0.7450	0.8338	Fail	0.1064
14	0.8800	0.7150	0.7975	Fail	0.1034

Table 3



Average Blackbody Emissivity Polarization for Type II Anodized Aluminum
Blackbody Emissivity
1
0.98
0.96
0.94
0.92
0.9
0.88
0
10
20
30
40
50
60
70
80
90
100
Weighting Factor (% Single Bounce)
4µm
5µm
6µm
7µm
8µm
9µm
10µm
11µm
12µm
13µm
14µm

Figure 1



Average Blackbody Emissivity Polarization for Type II Anodized Aluminum
Blackbody Emissivity
1
0.999
0.998
0.997
0.996
0.995
0.994
0.993
0.992
0.991
0.99
0.989
0.988
MODIS Specification
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Weighting Factor (% Single Bounce)
4μm
5μm
6μm
7μm
8μm
9μm
10μm
11μm
12μm
13μm
14μm

Figure 1a

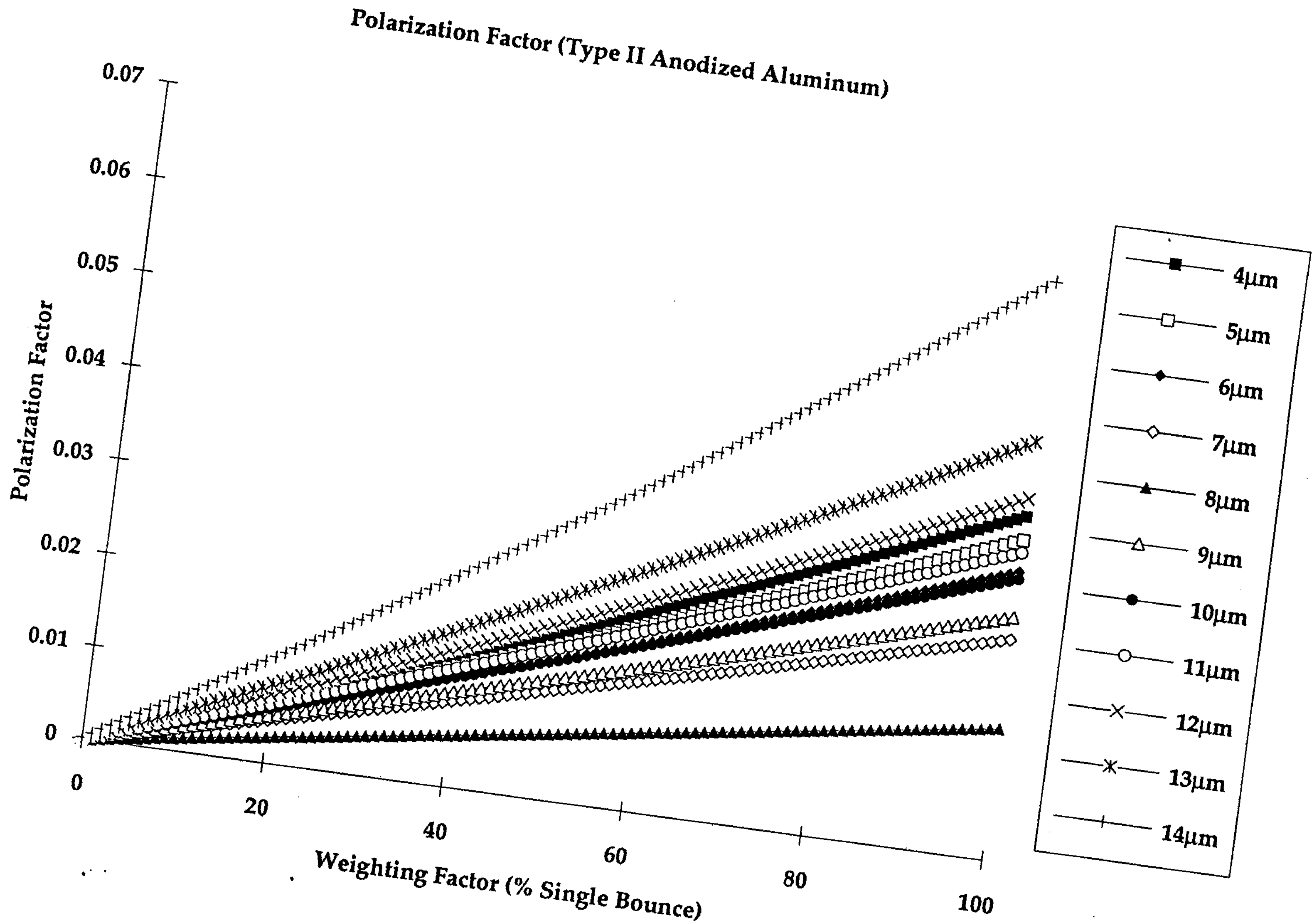

Polarization Factor (Type II Anodized Aluminum)
Polarization Factor
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
20
40
60
80
100
Weighting Factor (% Single Bounce)
4µm
5µm
6µm
7µm
8µm
9µm
10µm
11µm
12µm
13µm
14µm

Figure 2

Polarization Factor (Type II Anodized Aluminum)

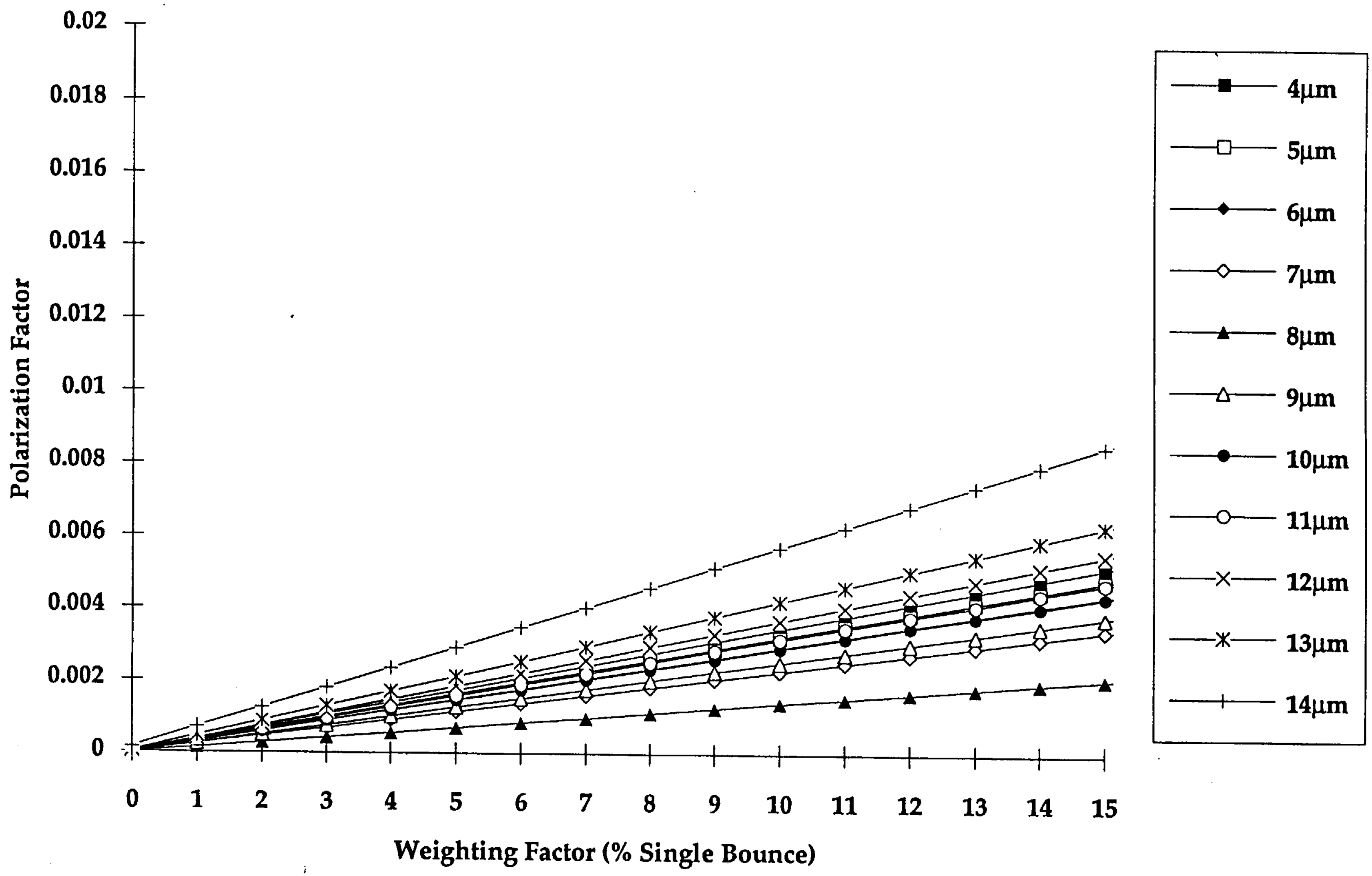


Figure 2a

Average Blackbody Emissivity Polarization for Type III Anodized Aluminum

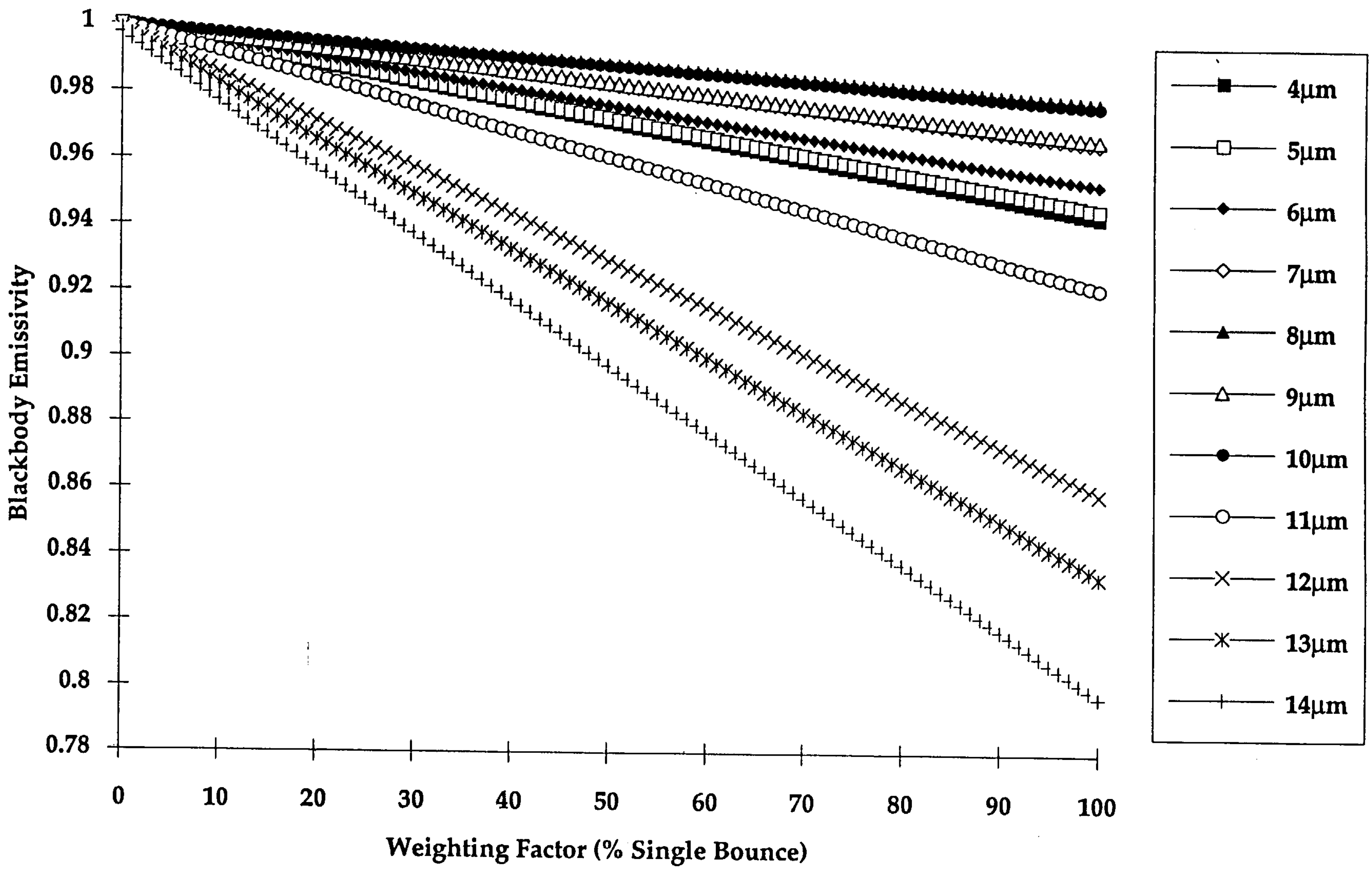
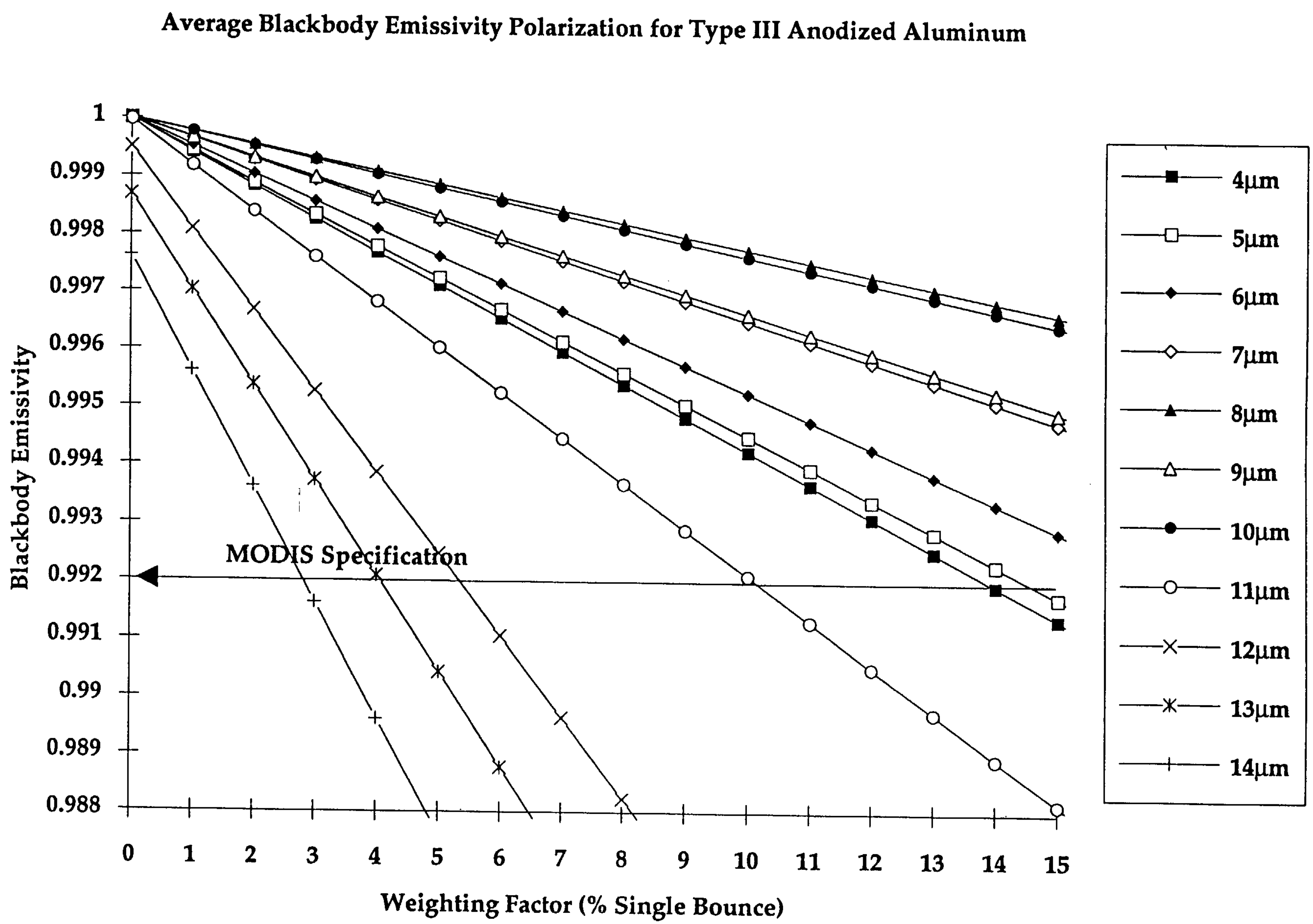


Figure 3



Average Blackbody Emissivity Polarization for Type III Anodized Aluminum
Blackbody Emissivity
1
0.999
0.998
0.997
0.996
0.995
0.994
0.993
0.992
0.991
0.99
0.989
0.988
MODIS Specification
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Weighting Factor (% Single Bounce)
4µm
5µm
6µm
7µm
8µm
9µm
10µm
11µm
12µm
13µm
14µm

Figure 3a

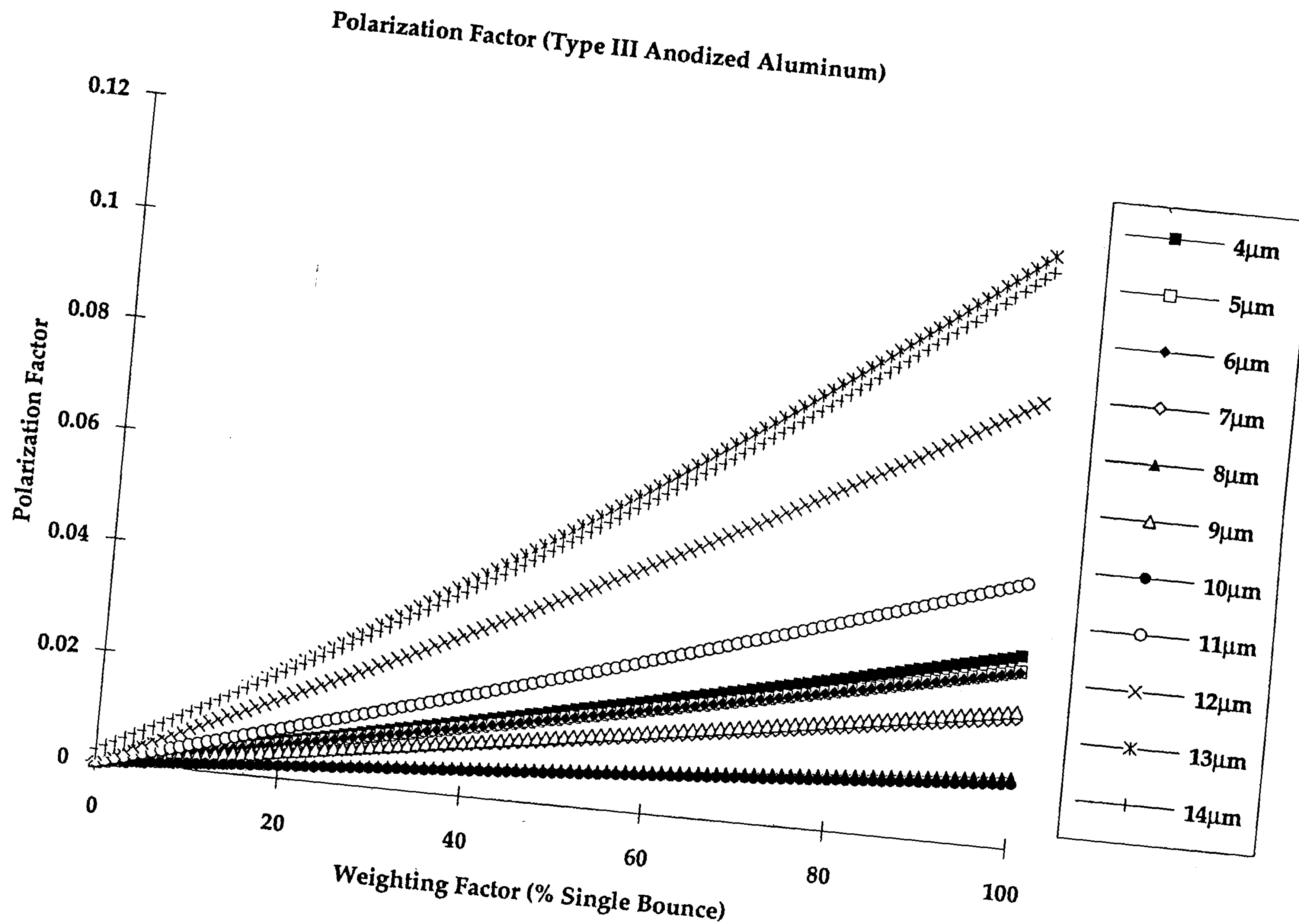
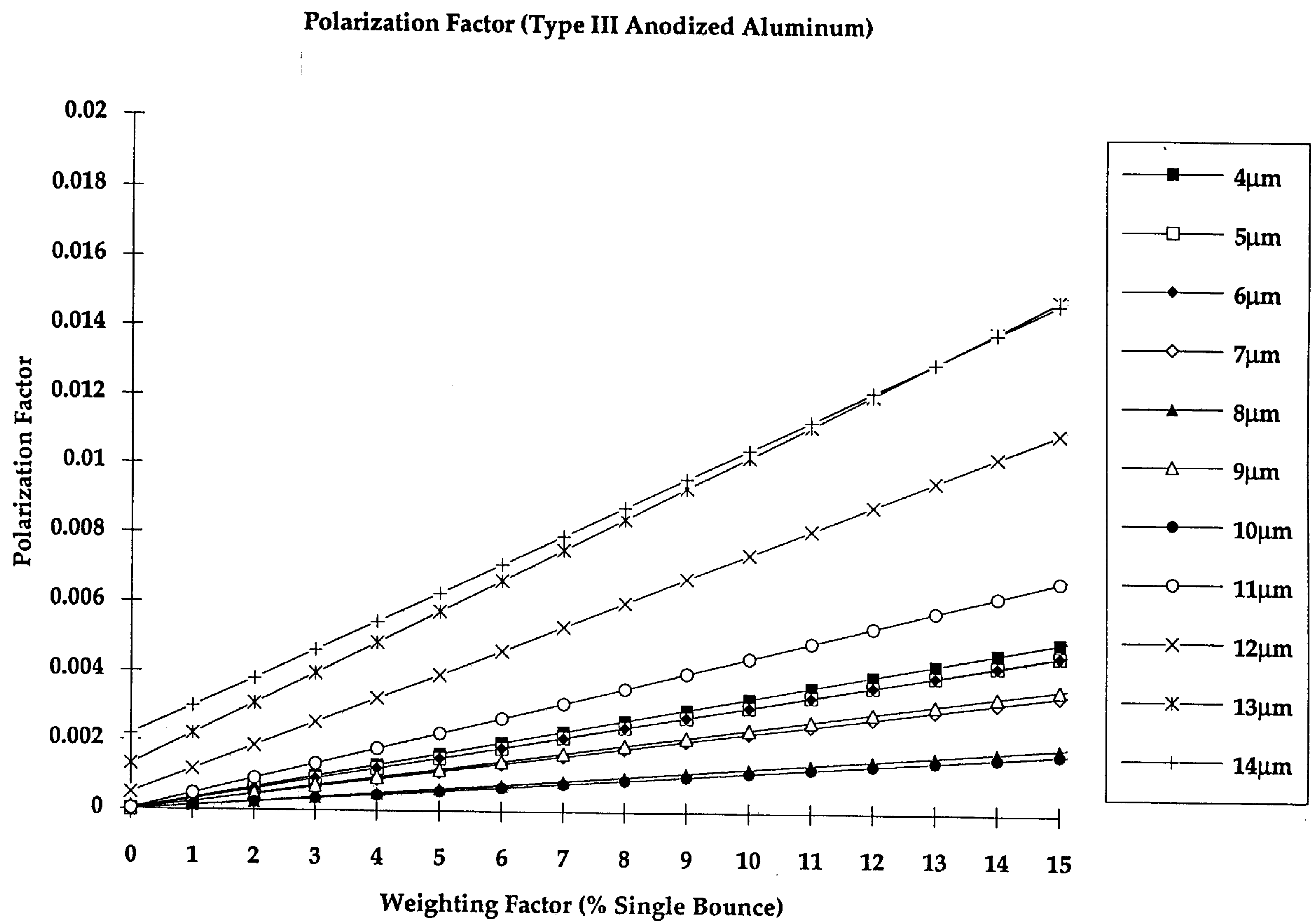

Polarization Factor (Type III Anodized Aluminum)
Polarization Factor
0.12
0.1
0.08
0.06
0.04
0.02
0
0
20
40
60
80
100
Weighting Factor (% Single Bounce)
4μm
5μm
6μm
7μm
8μm
9μm
10μm
11μm
12μm
13μm
14μm

Figure 4



Polarization Factor (Type III Anodized Aluminum)
Polarization Factor
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Weighting Factor (% Single Bounce)
4μm
5μm
6μm
7μm
8μm
9μm
10μm
11μm
12μm
13μm
14μm

Figure 4a